FINAL REPORT

THE LOWERING OF A COMMUNITY'S DRINKING WATER SODIUM CONCENTRATION HAS NO EFFECT UPON ADOLESCENT BLOOD PRESSURES

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MARCH, 1987

PREPARED FOR
AMERICAN WATERWORKS ASSOCIATION RESEARCH FOUNDATION
CONTRACT #H-82
AND
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATER POLLUTION CONTROL

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CONTRACT #85-15

ABSTRACT

Previous investigations established that elementary and high school students residing in Reading, Massachusetts, displayed significantly higher blood pressure than their counterparts in the adjacent community of Stoneham, Massachusetts. Extensive evaluations of family history, dietary patterns, socio-demographic variables and chemical measurements of drinking water revealed that the level of sodium in the drinking water was the variable most strongly associated with the higher blood pressure of the Reading students. A subsequent study, in which a group of Reading fifth graders' families was given Stoneham water for all drinking and cooking purposes for a three month period, indicated that female but not male students displayed a significant decrease in their blood pressure.

Based upon these findings, and the intention of the Town of Reading to reduce sodium levels in the drinking water by switching from the use of NaOH to CaOH as a pH adjustment technique, a study was proposed to assess the impact of such a change in drinking water sodium levels (i.e. 120 mg/L to 35 mg/L) on the blood pressure distribution of Reading school children. The study design included a comparison of the blood pressure values of Reading and Stoneham eighth grade students taken just prior to the proposed change in the drinking water to blood pressure values one year after the new treatment facility was operational. Because of unanticipated and prolonged problems in the construction and initial operation of the plant, the blood pressure retesting occurred two and a half years after the initial blood pressure screening, and ten months after the Reading water treatment plant had been operating with consistently lowered levels of sodium (35 mg/L). The study indicated that the reduction in sodium concentration in the Reading drinking water did not lead to a reduction in blood pressures in the Reading adolescents studied.

INTRODUCTION

Background

The question of whether consumption of drinking water with elevated levels of sodium (Na) affects the blood pressure (BP) of school aged children has been the basis of considerable epidemiologic research and much debate. Initial studies by the authors [1,2,3] reported a direct association between the presence of elevated levels of Na in drinking water and the distribution of BP among both elementary and high school students. These initial findings led a number of investigators to additional research efforts which were designed to validate and extend the original studies. These investigations collectively resulted in an ambivalent scientific disposition. Several of the follow-up studies [4,5,6] supported the original findings [1,2] while other epidemiologic investigations did not confirm the initial association. [7,8] With the exception of the intervention study of Calabrese and Tuthill [4] and a later study by Tuthill and Calabrese [9] all other studies were of a cross-sectional epidemiologic nature and as such were more likely to describe associational rather than causal relationships.

In light of the unresolved nature of the issue, it was recognized by the authors that epidemiologic efforts to clarify the problem should be directed to experimental study designs where causation could be more easily ascribed. The following epidemiologic study was designed to assess the impact of a lowering of Na in drinking water (from 120 to 35 mg/L) on the blood pressure of public school students in Reading, Massachusetts.

Prior Studies

In the 1970's, routine water supply testing by the State indicated the town of Reading, Massachusetts had a range of concentration of 110 mg/L - 120 mg/L of Na in its drinking water. Approximately 35 mg/L was attributed to contamination of the water supply by road salt run-off, 8 mg/L to natural background, and the remainder was due to water treatment with sodium hydroxide. These levels of Na were the highest in potable water supplies statewide. [1,2]

During the late 1970's several studies [1,2] were carried out by the current investigators to assess whether the elevated level of Na in the public drinking water had any effect on the blood pressure of school children. For the purposes of most of these studies the blood pressures of school children in Reading were compared with their counterparts in a geographically contiguous community (Stoneham, MA) with a similar socioeconomic background but with drinking water supplied from the Metropolitan District Commission Quabbin Reservoir with a background level of 8 mg/L of Na.

The first cross-sectional study in 1977 [1,2] compared the blood pressure distribution of 10th grade students in Reading with similar students in the Stoneham schools. Reading girls were found to have a blood pressure on the average of 5 mm mercury (Hg) higher and the boys about 3 mm Hg higher. For the girls this was equivalent to the group being about 10 years older as related to their Stoneham peers. For the boys the age effect was equivalent to several years. A subsequent study [3] of third graders in the same two communities in 1978 supported the earlier results with both

sexes showing about 3 mm Hg difference for both systolic and diastolic BP.

In 1979, an intervention study [4] using bottled water was carried out to assess the effect on BP of lowering Na concentration in the water of the Reading (HiNa) community children. Trios of children were matched by sex, school and baseline BP. For three months bottled water was provided for all cooking and drinking purposes in their homes and for drinking at school.

The pupils were randomly allocated to three water conditions: (1) high Na water (120 mg/L) bottled from their own distribution system, (2) low Na water (8 mg/L) bottled from the distribution system of Stoneham with Na added to equal the Reading water (120 mg/L), and (3) low Na water (8 mg/L) from Stoneham with no extra Na added. The mean BP among girls in the LoNa water group showed a statistically significant decrease of 1.7 to 2.7 mm Hg compared to the other two HiNa girls' groups at the end of three months. The initial greater decrease in BP for the boys' LoNa group disappeared after the first month.

By 1980, the town of Reading had a need to increase its water supplies and decided at that time to upgrade its treatment facilities including a change from sodium hydroxide to calcium hydroxide for softening the water. According to the town's public works director, the decision to shift to lime softening was strongly influenced by the community's increased awareness of the Na issue due to our prior work in the community. The expected drop of the Na concentration in the drinking water provided an opportunity to assess what effect a reduction in Na in the drinking water would have on the BP of community adolescents.

METHODS

During the fall of 1982, just as construction was beginning on the new water treatment plant in Reading, the investigators obtained blood pressure readings on 8th grade students in Reading and Stoneham. The strategy was to repeat the readings in both groups a year after the new plant went on line and to compare the change in blood pressure between the two groups over time. Assuming that Reading teens would have a higher average BP at initial screening, the specific hypothesis was that the difference in the distribution of blood pressure between the two communities would decrease. Although BP would rise in the students in both towns as they got older, the reduction of the Na in the Reading water would lower the BP somewhat in the Reading students and partially offset the rise in BP with growth and development, thus reducing at follow-up the differences in BP found at the initial screening. Previous research[4] has suggested that a reduction of Na is followed rather quickly by a reduction in blood pressure.

Although the initial BP screening of the 8th graders was completed in the fall of 1982 as scheduled, the follow-up phase had to be postponed due to delays in the construction schedule, slow delivery of equipment and problems with the initial operation of the lime softening plant. The rescreening of the same students occurred during the Spring of 1985 when they were 10th graders. At this point the Reading water treatment plant had been operating consistently with lower levels of Na (35 mg/L) for over ten months.

Blood Pressure Screening Techniques

In order to minimize the effects of recent food intake and the effects of exercise on BP, the students were screened at least 45 minutes after a meal and they did not attend gym class at least one hour before being screened. The students were brought quietly to the screening area and spent at least six minutes seated, completing a questionnaire, before proceeding to the screening stations.

The students progressed through three screening stations where each nurse took a casual, seated BP reading on the left arm. The nurses were blind to the previous reading(s) for each person. The nurses rotated through the stations, with only three of the four working at any given time. The BP readings were made at eye level using a mercury sphygnomanometer. Systolic BP was recorded as the point where the first of two consecutive Korotkoff sounds were audible and diastolic BP was recorded as the disappearance of sound. The three BP readings were averaged to provide an estimate of BP for each individual. Pulse rate was recorded at the first station as the number of heart beats in 30 seconds multiplied by two. Height and weight were recorded by a separate technician after the third BP. Weight was recorded to the nearest half pound on an electronic scale and height to the nearest quarter inch on a wall mounted rule using a right angle height indicator.

One group of nurses took the BP in the 8th grade and a second different group recorded BP in the 10th grade follow-up. However, at both times the nurses involved screened both the Reading and the Stoneham students. The rotation of nurses among the stations was arranged so that each nurse

screened the same proportion of students in the two communities. At both points in time the nurses were blind to the hypothesis being tested.

The registered nurses were recruited through regional Visiting Nurse Associations. The nurses involved in the study were screened from a larger pool on the basis of both agreement with each other, and agreement with themselves, on repeated measures in response to a BP training film. They were then trained in a standardized technique for the purposes of our study and validated by a staff member of the Multiple Risk Factor Intervention Trial project in Cambridge, Massachusetts. The pressure was raised approximately 30 mm Hg above the point where the pulse disappeared and then released at the rate of 2-3 mm Hg per second. A dual stethoscope was used to validate the nurses who had to agree with the validator to within 2 mm Hg on several consecutive BP readings on adolescent volunteers. These procedures were the same as those used in the third grade [3] and later studies [4,9] reported in the literature.

Questionnaire Data

There were two questionnaires, one filled out by the students and one by the parents. The student questionnaire included information on sex, health rating, physical activity level, recent weight gain or loss, age, years of residence, medication taken for high blood pressure, recent lunch, recent gum chewing, cigarette smoking in the last hour, amount of salt added to food at the table, and detailed information on liquid consumption.

The parent questionnaire included information on high blood pressure history of biologic relatives, use of bottled water in the home, whether bottled water was used for drinking and cooking, the presence or absence of

a home water softener, and the education and occupation of parent(s).

Sodium Intake from Liquid Sources and Snack Foods

A separate snack food questionnaire queried frequency of consumption per month of eighteen high sodium fast food and snack food items which for the purposes of this paper are termed solid food. This food questionnaire was used to calculate an estimate of average daily intake of Na from high Na food sources frequently consumed by adolescents.

In addition, the detailed information on liquid consumption provided data on total liquid intake consumed the prior day. Amount of water drunk was categorized as at home, school, or other location. Mixed drinks included frozen juices or fruit drinks, hot drinks such as coffee, tea or cocoa, and soups. Other liquids included milk, soft drinks, fruit and/or vegetable drinks from cans or cartons, and other liquids. The information on water consumption was combined with parental reports of bottled water use at home to determine Na intake from water. This value was added to other liquid intake to determine daily Na intake from liquid sources.

Ultimately, snack food Na intake and liquid Na intake was combined to give an estimate of partial daily Na intake. Daily diary records or recalls were not collected to account for other sources of Na in the diet.

Water Sample Collection

Several weeks subsequent to the follow-up blood pressure screening, a sample of students in both communities were asked to obtain a sample of their home tap water. The students in each community were cross-classified into twenty-five groups based upon their quintiles (fifths) of systolic and diastolic BP. A twenty-five percent random sample was

drawn from each group.

Each student was given a small plastic screw top 200 ml bottle (3 1/2" x 2 1/2" x 1") and a set of instructions for obtaining a "first morning" water sample from the bathroom faucet. The water samples were turned in to the investigators when the students came to school, and delivered several hours later to the Lawrence Experiment Station of the Commonwealth of Massachusetts.

The samples were analyzed by flame atomic absorption spectrometry for the concentrations of sodium, potassium, calcium, magnesium, copper, cadmium and lead, and titrimetrically for chloride.[10] These elements were chosen because of their known or suspected relationship to cardiovascular disease or blood pressure. At the time of the baseline screening, data were collected on sodium, calcium, copper, cadmium, and lead in a similar manner. Other data were available on chloride from distribution system samples drawn for routine analysis for the State Department of Environmental Quality Engineering at about the same time.

RESULTS

At the time of the baseline survey in the fall of 1982, the 279 eighth graders who participated in Reading and the 253 students from Stoneham represented some 78 percent and 74 percent of eight graders, respectively. Contrary to the results of the previous studies of 10th and 3rd graders in the same two communities, the 8th graders in Reading in this study had lower, rather than higher, blood pressures than their Stoneham counterparts with differences of 5 mm Hg systolic and 2mm Hg diastolic. T-test results

indicated these differences were significantly at $p<0.05$.

Both screenings were available to all students attending the schools at the time of the screening. For purposes of testing the study hypothesis, however, the appropriate comparison is between the students who participated at both points in time. Since not all the students who were screened in the 8th grade participated in the 10th grade, this created a possible non-representative group at follow-up.

Table 1 compares the mean BP of those 8th graders who dropped out of the study after the eight grade to the mean 8th grade BP of those who were also participants in the 10th grade screening also. The difference between the drop-out and continuous groups for systolic BP ranged from 0.4 to 1.5 mm Hg, but reduced the differences between Reading and Stoneham students by 0.5 mm Hg. For diastolic BP there were somewhat larger differences ranging from - 1.1 mm Hg to +2.3 mm Hg which changed the differences between Reading and Stoneham in the amount of +0.5 mm Hg for females and -3.4 mm Hg for males. Please note from this table that the ratio of male to female continuers is virtually identical in both communities and thus sex cannot act as a confounder. For this reason, in conjunction with increasing statistical power, all additional figures and tables are presented without regard to sex grouping.

Figures 1A and 1B show the distribution of change in BP between the 8th and 10th grades for both communities. Reading showed a greater increase in systolic BP of 1.2 mm Hg, and for diastolic BP an increase of 3.4 mm Hg, but only the latter difference was statistically significant.

Among the personal characteristics of the students and variables from

the parent questionnaire, only change in pulse rate and change in weight differed between the communities and were also related to BP. Figure 2 shows the distribution of change in pulse rate for the two communities. The mean pulse rates of both communities decreased but Reading dropped almost 2 beats less, a difference that was statistically significant at $p=0.021$.

As indicated in Figure 3, the Reading students' weight gain averaged 4 pounds greater than their Stoneham counterparts, a difference which was statistically significant at $p=0.048$. Both change in pulse rate and change in weight were also statistically significantly associated with change in BP in the study group. An analysis of covariance was used to adjust change in BP for change in pulse and weight.

In the upper part of Table 2 the unadjusted difference in systolic BP between the communities was 1.23. When adjusted for change in pulse rates the difference in systolic BP change decreased to 0.78. When adjusted for change in weight alone, the systolic BP change difference was reduced to 0. Adjusting for both variables simultaneously reduced systolic BP change difference to -0.49. Although the unadjusted difference in change in systolic BP was not statistically significant to begin with, the significant contribution of the co-variates of pulse change and weight change reduced the difference to essentially zero.

Diastolic BP change is considered in the lower half of Table 2. Only change in weight significantly affected the difference in diastolic BP change between communities. However, even then, the adjusted difference in diastolic BP change (2.98 mm Hg) remained significant at $p=.005$.

Reported Daily Sodium Intake

Table 3 indicates the reported daily Na intake in Reading and Stoneham from high Na snack foods, drinking water and other liquids but does not include other sources of dietary intake. The difference between the two communities in total daily Na intake was 110.3 milligrams, an over-all difference which was not statistically significant. Reading students reported a 6.3 percent higher partial sodium intake than those in Stoneham. The difference in NA intake of 22.5 milligrams from drinking water between the two groups was highly statistically significantly different ($p < 0.0001$).

This 22.5 milligrams difference represented 20 percent of the 110.3 excess milligrams of sodium ingested daily by the Reading students. Table 4 demonstrates that adjusting for individual estimated Na intake (fast foods, water and other liquids) does not appreciably reduce the difference in change in BP over time. Average differences in systolic BP Table 4 demonstrates that adjusting for individual estimated Na intake (fast foods, water and other liquids) does not appreciably reduce the difference in change in BP over time. Average differences in systolic BP were reduced from 1.23 to 0.94 mm Hg when accounting for solid food Na intake. The largest decline for diastolic BP was from 3.46 to 3.23 mm Hg for the solid food category. Figure 4 illustrates the distribution of partial total daily Na for the two groups of students, graphically demonstrating the similarities.

Water Analysis

At the time of the follow-up collection, some thirty-three of the seventy Reading students (47.1%) and twenty-three of thirty-eight Stoneham students (60.5%) returned a water sample. Those who returned

the samples were dispersed throughout the communities and were not different in BP from the larger study group. Selected characteristics of the two community water supplies are displayed in Table 5. These data are presented in non-parametric format because of the skewed nature of the distributions. For the first four elements (Na, K, Ca, Mg), the distributions of the elements in the two communities did not overlap in that the minimum values for Reading were higher than the maximum values for Stoneham. For chloride the distributions overlapped, but this was due to only one sample in Stoneham with a value of 150 mg/L with the next highest value being only 14 mg/L. The median chloride values were 80 mg/L and 13 mg/L, respectively, for the two communities. The distribution of copper did not differ significantly between the communities. The levels of lead and cadmium were below detectable levels (<0.01 mg/L and <0.04 mg/L) for the two areas. As can be seen, the median concentrations of the other elements were 3.5 to 6.5 times higher in Reading than in Stoneham.

In assessing change in BP, not only the current differences in water characteristics are important but also the changes in concentrations in elements between the baseline and follow-up periods. Data were collected only for sodium, calcium, copper, cadmium and lead for the earlier time period. The Stoneham water supply characteristics showed no change over this time period. In Reading the sodium level dropped from a median of 120 mg/L to 37 mg/L, chloride concentrations decreased from 123 mg/L to 80 mg/L, and calcium increased from 13 mg/L to 29 mg/L. Lead and cadmium were below detectable levels and copper showed a slight decline.

DISCUSSION

In the earlier 10th and 3rd grade studies comparing the same communities [1,2,3], there was a consistent difference of 3 mm Hg higher average BP in Reading (Hi Na) as compared to Stoneham (Lo Na) students. However, at baseline in the current study, Reading 8th graders had lower average BP's (2.5-4.5 mm Hg) than their Stoneham counterparts. The lowering of the drinking water Na level in Reading, if exerting an effect on BP, should have resulted therefore in an increased difference in BP between the two communities at follow-up of the cohort two years later.

Since BP rises with age among adolescents, the average BP was higher at follow-up for both cohorts. The initial crude comparisons of the change in BP over time (8th-10th) showed a greater rise in BP in the Reading (reduced Na) compared to Stoneham (low Na) cohort of students. After controlling for weight gain and pulse rate, systolic BP change was similar in the two adolescent groups, but the diastolic BP gain remained higher in the Reading students.

A number of factors were explored which might have obscured the expected results. The initial studies in Reading increased residents' concerns and awareness of the high Na levels in their community drinking water. As a result a considerable proportion of the residents bought bottled water for drinking purposes. Although this figure is unknown for the community as a whole, 51 percent of the tenth grade students at follow-up reported that their families bought bottled water. However, the comparison among Reading students from homes with bottled water against those from homes without bottled water showed no differences in change in BP from

8th to 10th grade. This lack of effect remained even when restricting the bottled water user group to those buying water for more than a year.

Differences in Na intake from other sources was also considered. Although it was not possible to obtain complete diet histories from the students, they were asked about usual consumption of high Na snack foods and liquid sources of Na. Controlling for this variable did not change the negative results even though Reading students had a 6.3 percent higher recorded Na intake (110mg) than Stoneham students. Drinking water Na concentration did account for 20 percent of the difference in recorded Na intake between the two communities.

Drop-outs from the original 8th grade cohort averaged 0.5 mm Hg lower BP in Reading than Stoneham students. Since lower BP at initial screening was related to a greater increase in BP at follow-up, the drop-out BP factor could not mask a drinking water Na reduction effect. Similarly, the BP screening nurses were not a source of masking since they were blind to the purpose of the study and each nurse screened a similar proportion of students in both communities.

As a result of the new water treatment process, the community drinking water in Reading showed decreases in Na (120 mg/L to 37 mg/L) and chloride (123 mg/L to 87 mg/L) but an increase in calcium (13 mg/L to 29 mg/L). Since lower levels of Na and chloride have been associated with lower BP values in animal and human models, while higher calcium is thought to play a protective role in BP [11], the changes in drinking water characteristics in Reading should have been beneficial and lowered the children's BP relative to their Stoneham peers. However, no obvious BP

effects of these changes in drinking water constituents was observed. However, the changes in these drinking water constituents represented but a small percentage of the total daily intake of these elements. [12]

Because of the BP tracking phenemenon, children on the upper end of the BP distribution tend to become adults with high BP. Children can thus serve as a sensitive barometer for the community BP experience. The study results clearly indicated that a reduction of Na concentration in the Reading drinking water from 120 mg/L to 37 mg/L did not lead to a reduced increase in the BP of adolescents. Thus, reducing drinking water Na concentrations may not lead to lower community BP levels. The reason(s) for a lack of a Na drinking water effect in this study as compared to the authors' earlier work remains unknown.

Acknowledgement

This research was supported in part by the American Waterworks Research Foundation Contract #H-82, and by the Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control Contract #85-15.

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Table 1: COMPARISON OF AVERAGE EIGHTH GRADE BP

BETWEEN DROP-OUTS AND CONTINUERS

	DROP-OUTS 8th ONLY		CONTINUERS 8th & 10th		DIFFERENCE Δ
	n	$\bar{X}$BP	n	$\bar{X}$BP	
SYSTOLIC 8th S. D. 9-10 mm Hg					
Reading Males	110	108.8	60	109.7	+0.9
Stoneham Males	82	113.9	63	114.3	+0.4
Δ		-5.1		-4.6	-0.5
Reading Females	49	107.3	60	108.8	+1.5
Stoneham Females	46	112.0	62	113.0	+1.0
Δ		-4.7		-4.2	-0.5
DIASTOLIC 8th S. D. 7-8 mm Hg					
Reading Males		64.8		67.1	+2.3
Stoneham Males		68.8		67.7	-1.1
Δ		-4.0		-0.6	-3.4
Reading Females		68.2		68.4	+0.2
Stoneham Females		70.6		71.3	+0.7
Δ		-2.4		-2.9	+0.5

FIGURE 1A: CHANGE IN SYSTOLIC BLOOD PRESSURE BY COMMUNITY
8TH TO 10TH GRADE

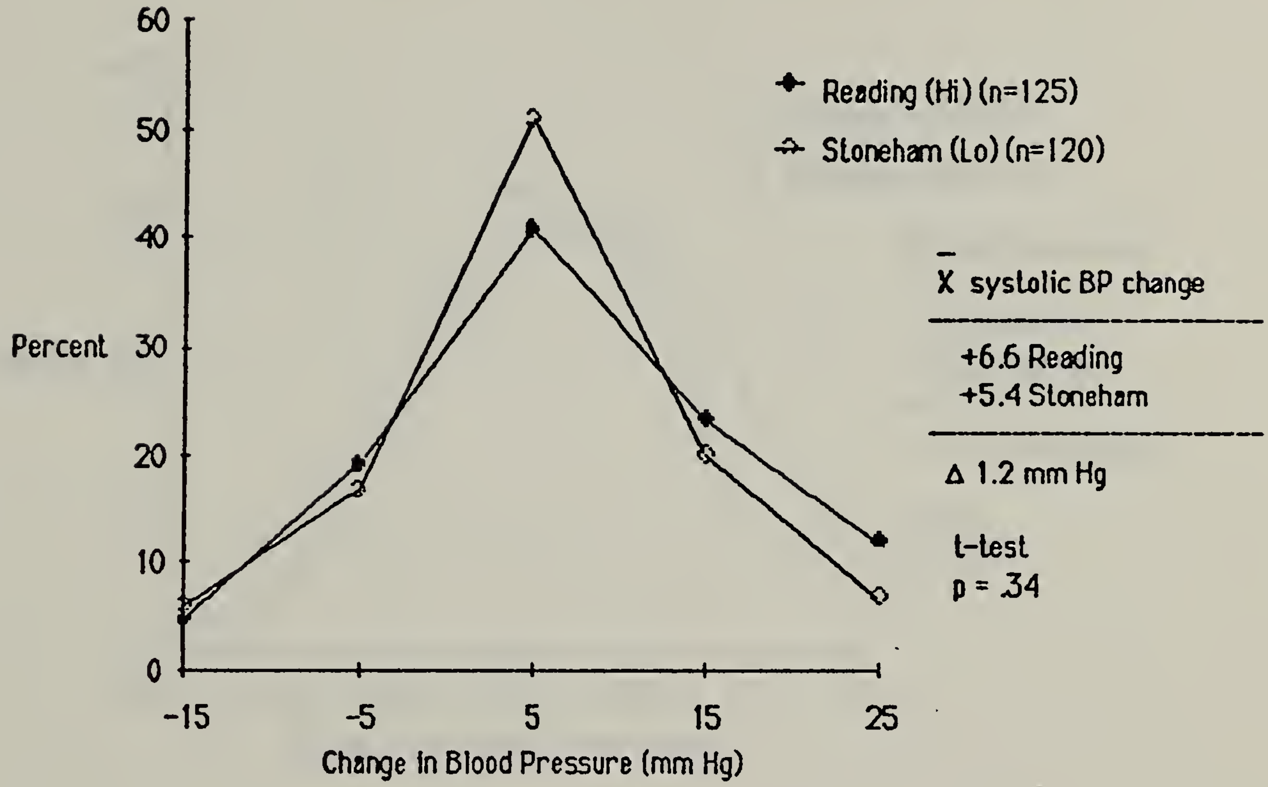

FIGURE 1B: CHANGE IN DIASTOLIC BLOOD PRESSURE
8TH TO 10TH GRADE

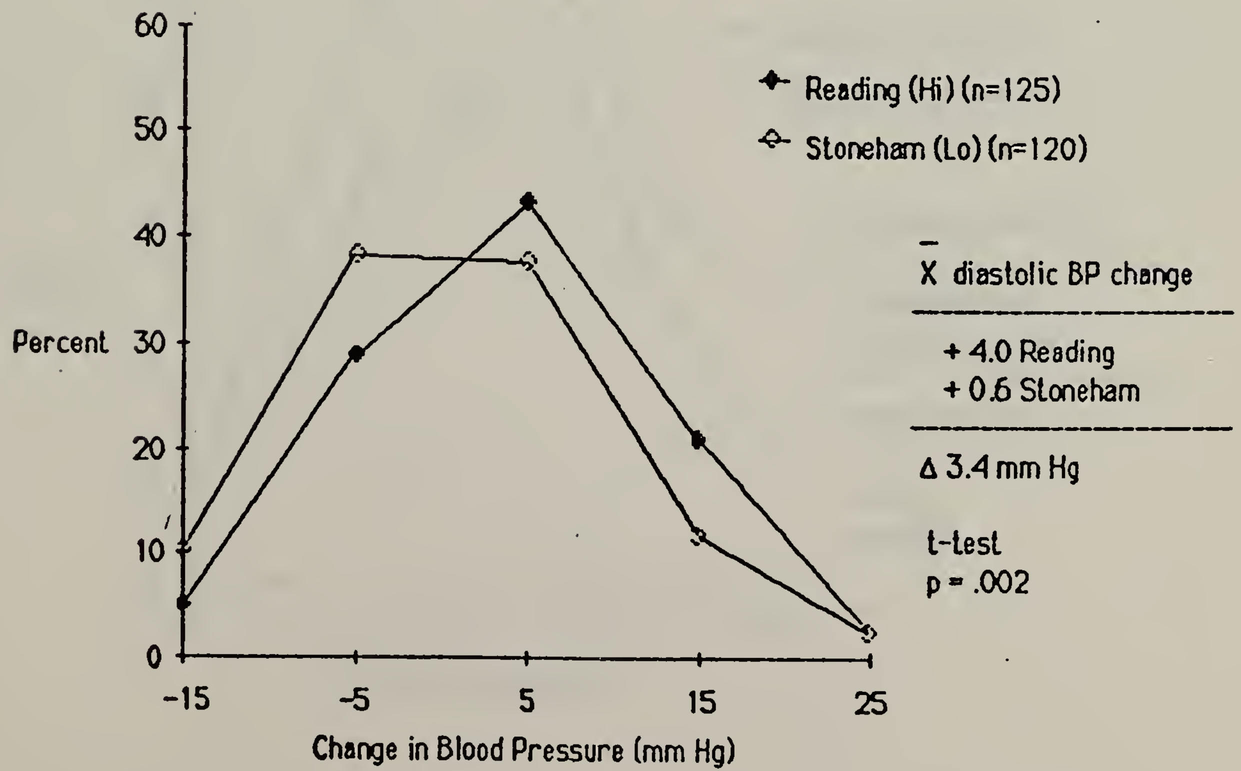

FIGURE 2: CHANGE IN PULSE RATE BY COMMUNITY
8TH TO 10TH GRADE

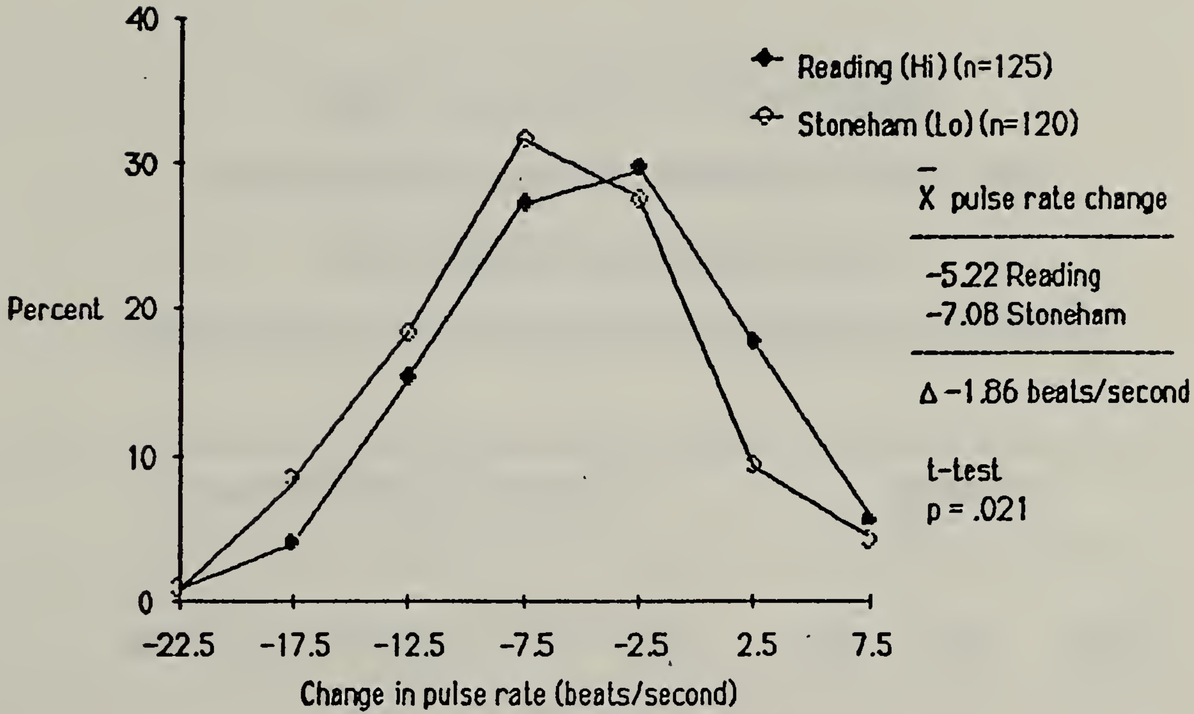

FIGURE 3: CHANGE IN WEIGHT BY COMMUNITY
8TH TO 10TH GRADE

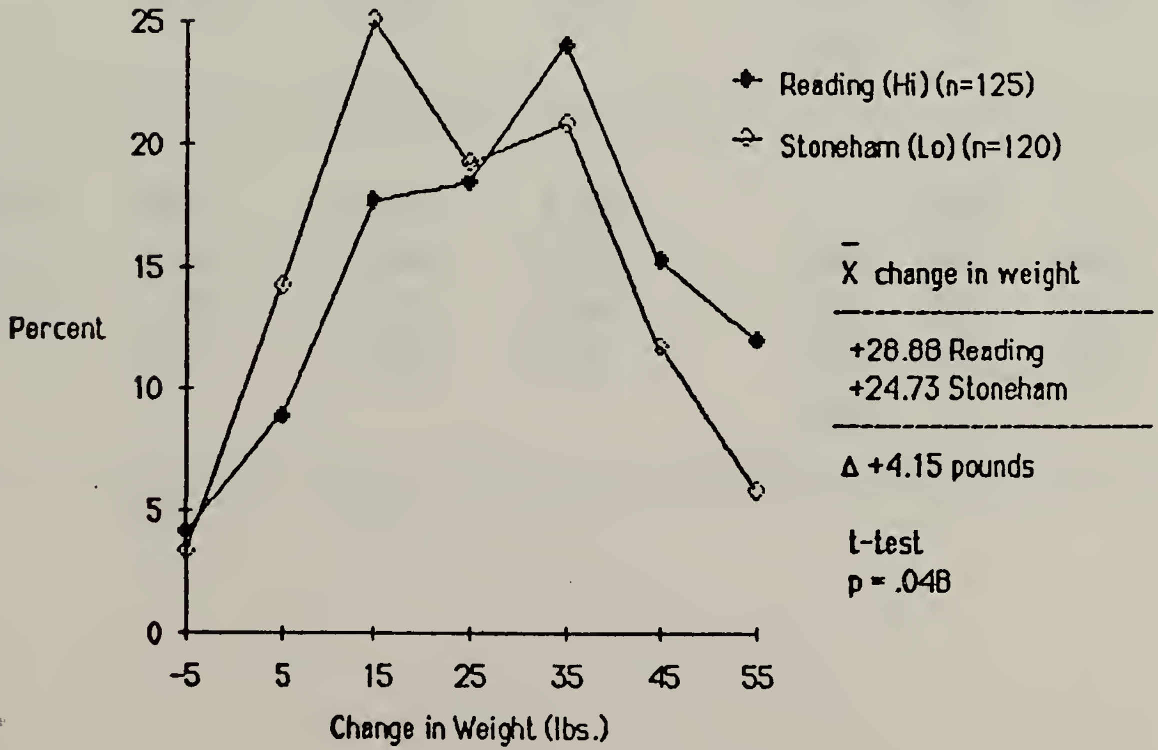

Table 2: ANALYSES OF COVARIANCE

MEAN BLOOD PRESSURE CHANGE BY TOWN, AND

DIFFERENCES BETWEEN TOWNS

UNADJUSTED, AND ADJUSTED FOR PHYSICAL FACTORS

	Mean BP Change (mm Hg)			p-value		
	Reading	Stoneham	Difference	cov.	main	total
SYSTOLIC						
Unadjusted	6.61	5.38	1.23	----	.336	----
Pulse diff.	6.39	5.61	0.78	.014	.540	.040
Weight diff.	6.01	6.01	0.00	.001	.998	.001
Both	5.77	6.26	-0.49	.004	.657	.001
				.001		
DIASTOLIC						
Unadjusted	4.03	0.57	3.46	----	.002	----
Pulse diff.	4.16	0.44	3.72	.267	.001	.002
Weight diff.	3.80	0.82	2.98	.001	.005	.001
Both	3.92	0.69	3.23	.275	.003	.001
				.001		
n	125	120				

Table 3: REPORTED DAILY SODIUM INTAKE (Milligrams)

	READING	STONEHAM	Δ	t-test p-value
HIGH NA SNACK FOODS	1334.0	1207.2	126.8	.353
DRINKING WATER	34.0	11.5	22.5	.0001
OTHER LIQUIDS	479.9	519.0	-39.1	.618
PARTIAL TOTAL DAILY NA	1847.9	1737.7	110.3 6.3%	.492

Table 4: ANALYSES OF COVARIANCE: MEAN BLOOD PRESSURE CHANGE AND DIFFERENCES BETWEEN TOWNS UNADJUSTED, AND ADJUSTED FOR <u>SODIUM INTAKE</u>

	Mean BP Change (mm Hg)			p-value		
	Reading	Stoneham	Difference	cov.	main	total
SYSTOLIC						
Unadjusted	6.61	5.38	1.23	----	.336	----
Liquid Na	6.63	5.37	1.26	.183	.324	.254
Solid Fd Na	6.47	5.53	0.94	.001	.447	.001
Total Na	6.51	5.49	1.02	.001	.412	.001
DIASTOLIC						
Unadjusted	4.03	0.57	3.46	----	.002	----
Liquid Na	4.04	0.57	3.47	.940	.002	.007
Solid Fd Na	3.92	0.69	3.23	.001	.002	.001
Total Na	3.96	0.65	3.31	.001	.002	.001
n	125	120				

FIGURE 4: PARTIAL TOTAL DAILY SODIUM INTAKE BY COMMUNITY
8TH TO 10TH GRADE

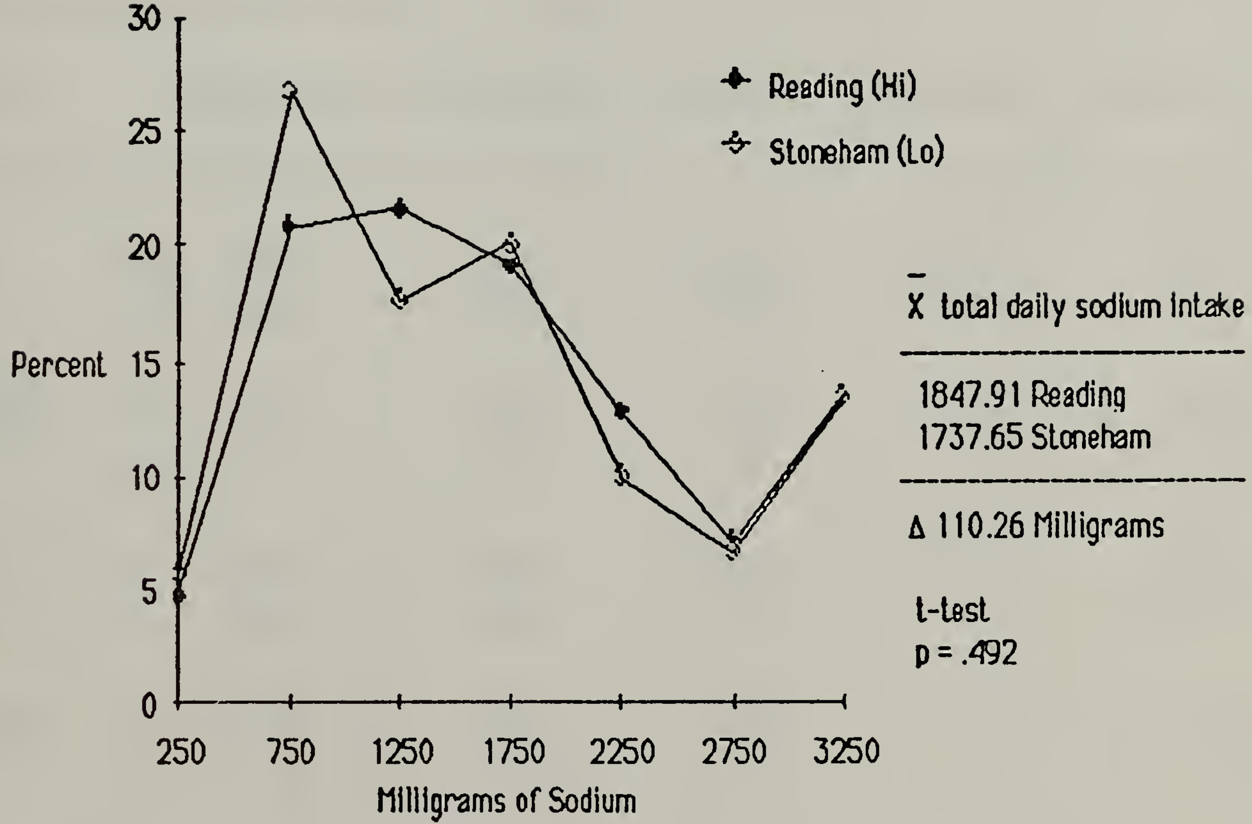

Table 5: Concentrations (mg/L) of Six Elements in Reading and Stoneham Water Distribution Systems at 10th Grade Follow-up

Elements		Minimum	1st Quartile	Median	2nd Quartile	Maximum
Sodium	R*	20.0	36.0	37.0	39.0	43.0
	S*	9.2	9.5	9.6	10.0	10.0
Potassium	R	1.1	2.0	2.1	2.2	3.2
	S	.4	.6	.6	.7	.8
Calcium	R	15.0	29.0	29.0	31.0	31.0
	S	3.9	4.1	4.4	4.6	5.2
Magnesium	R	1.9	3.2	3.2	3.3	3.4
	S	.7	.7	.7	.7	.8
Chloride	R	14.0	75.0	80.0	85.0	180.0
	S	2.0	12.0	13.0	13.0	150.0
Copper	R	.01	.01	.02	.03	.05
	S	.01	.02	.03	.05	.82

*R=Reading (n=33), S=Stoneham (n=23)